

The Langley Standard Real-Time Simulation in C++ (LaSRS++)

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Topics

- ◆ What is LaSRS++?
- ◆ Features
- ◆ Scalability
- ◆ Portability
- ◆ Design Overview
- ◆ Virtual Environment
- ◆ Supported Simulations

What is LaSRS++?

- ◆ Langley Standard Real-Time Simulation in C++.
 - 1997 - All new simulation projects will use LaSRS++.
- ◆ An object-oriented application framework for constructing continuous cyclic simulations.
 - Built from scratch using modern object-oriented programming and design techniques. No legacy code.
 - A set of libraries that implement critical services for all simulations.
 - A simulation is LaSRS++ plus vehicle models.
 - Developers focus on vehicle model development. LaSRS++ provides everything else.

Major Features

- ◆ Supports multiple, heterogeneous models in a simulation.
 - Models not restricted to aircraft. Model can represent any interactive item.
- ◆ Multi-processor support. (In flux)
 - Can run N models on M processors.
 - Can divide a model across processors.
- ◆ Vehicle models portable across simulators.
 - May require additional “hardware interface” code.

Major Features (cont.)

- ◆ True inertial equations of motion.
 - Earth does not need to be fixed in space. It can translate and rotate.
- ◆ Supports multiple “worlds” in a simulation.
 - Only the Earth is currently modeled.
- ◆ Cockpit recording and playback.
- ◆ Relative geometry between models.
- ◆ Graphical and character-based interfaces
 - Only graphical interface appropriate for real-time.

Model Features

- ◆ Customizable data recording
 - Records “sets” of data.
- ◆ Model playback.
- ◆ Trim algorithm
- ◆ Linear model generator
 - Three-point central difference
 - Detects changes in independent variables
- ◆ Triggers for limits on states.
 - Example: auto-hold

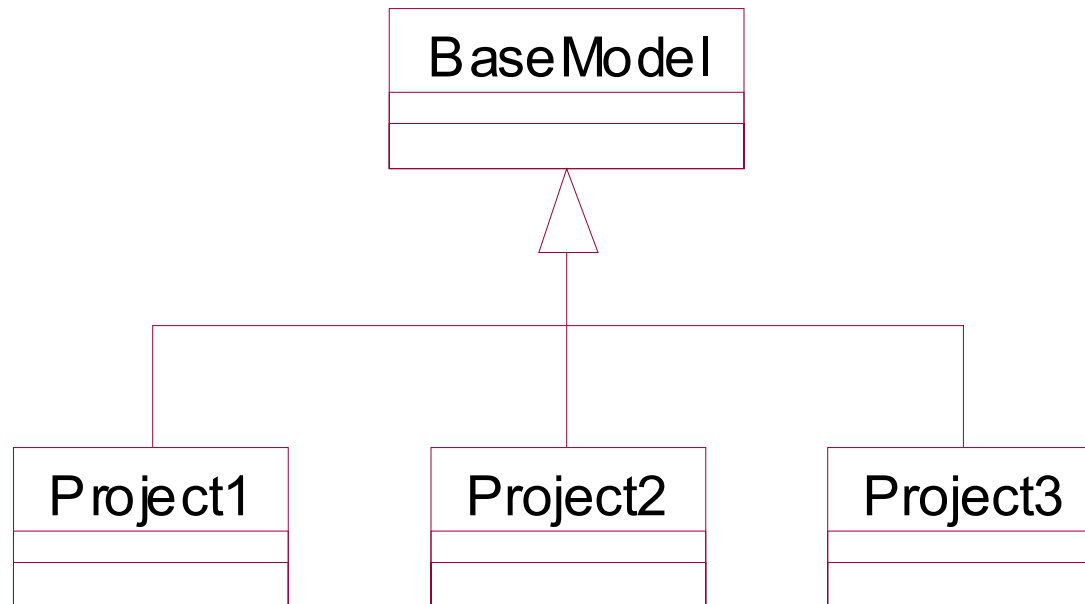
Major Features

- ◆ Virtual environment can operate at an integral multiple of the hardware I/O rate.

Model Features (cont.)

- ◆ Build-once and multiply
 - Multiple instances of a class can be constructed.
 - Classes are coded without regard to the number of instances.
- ◆ Project customization and isolation.
 - Projects using the same model inherit from it.
 - Projects share the structure and behavior of the base model.
 - Customizations are not visible to other projects.
 - Customizations easily promoted to base model.

Model Features (cont.)



World Features

- ◆ Each world has an atmosphere model, gravity model, and navigation database.
- ◆ Earth model features:
 - Flat, spherical, or ellipsoidal shape.
 - Constant and inverse-square-law gravity models.
 - ARINC-424 and user-defined navigation databases.
 - 1976 Standard Atmosphere model with modifiable sea-level temperature.
 - Constant wind model with first order turbulence.

EOM Features

- ◆ Six DOF
- ◆ Orientation stored as quaternions.
 - Avoids singularity in Euler angle representation.
- ◆ Integration
 - 2nd order Taylor series for position
 - Local linearization for quaternions (NASA TN D-7347)
 - 2nd order Adams-Bashforth for other states
- ◆ English units

Scalability

- ◆ Asynchronous and emulated real-time operation on desktops.
- ◆ Pilot-in-the-loop, synchronous hard real-time
- ◆ Simulation-to-Flight
- ◆ Many research projects using the same simulation.
 - Projects desire isolation from the changes introduced by other projects.
 - Some projects desire to share select changes.

Portability

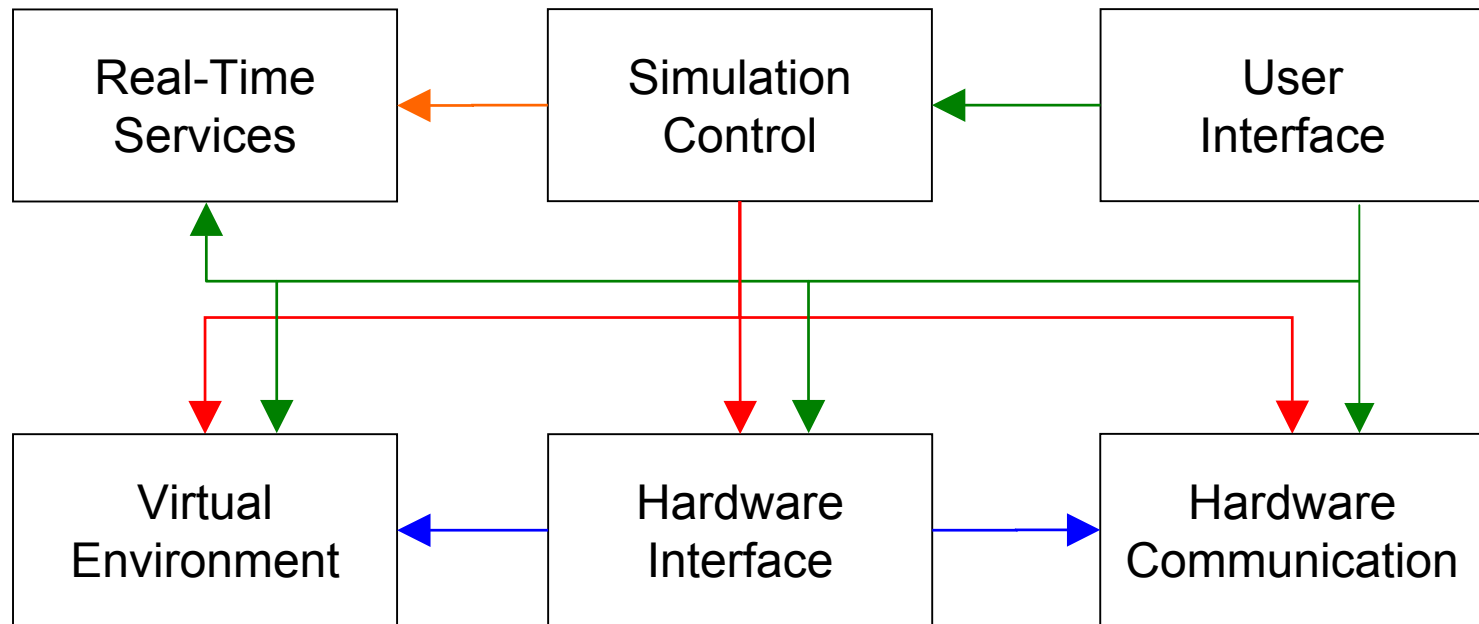
◆ Synchronous Real-Time

- IRIX 6

◆ Desktop operation

- IRIX 6
- Solaris 2.6
- Linux (In flux)
- WindowsNT (In flux)

Design Overview



Components

◆ Simulation Control

- Controls simulation construction and shutdown.
- Operates simulation event loop.
 - Exercises mode control and multi-process synchronization.
 - Directs hardware I/O and operates virtual environment.

◆ Real-Time Services

- Synchronizes simulation to external real-time clock.
- Performs synchronous I/O.

Components (cont.)

◆ User Interfaces

- Character-based and graphical.
- Accesses components through existing class interfaces.
 - Exists in the same address-space as simulation.
 - Graphical interface is a separate thread.

◆ Virtual Environment

- Models the world and interactive objects.
- Computes relative geometry between models.
- In the works: Can be re-hosted in another program.
 - Not coupled to other components.

Components (cont.)

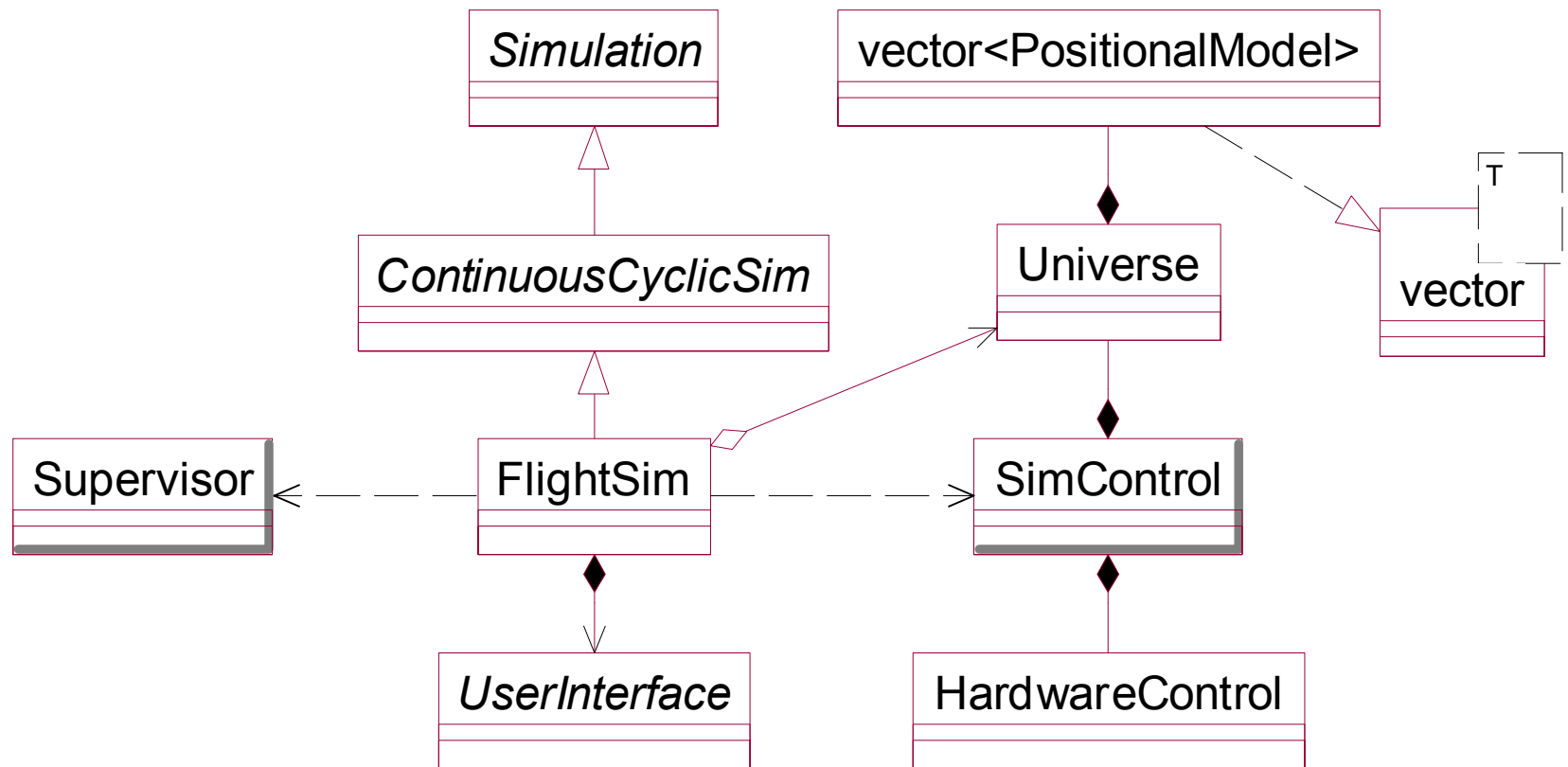
◆ Hardware Communication

- Transfers data between hardware and real-time host.
- Reused for diagnostic programs.
 - Not coupled to other components.

◆ Hardware Interfaces.

- Mediators between Hardware Communication and Virtual Environment.

LaSRS++ Top Level Design



LaSRS++ Classes

- ◆ Simulation
 - Abstract interface for executing simulations.
- ◆ ContinuousCyclicSim
 - A Simulation with concepts of mode based behavior and time that increments in fixed, discrete intervals.
- ◆ FlightSim
 - A ContinuousCyclicSim that operates a virtual reality.
 - Provides an interface for user interaction.
- ◆ Universe
 - The virtual reality containing worlds and models.

LaSRS++ Classes

◆ Supervisor

- Synchronizes simulation to external real-time clock.
- Performs synchronous I/O.

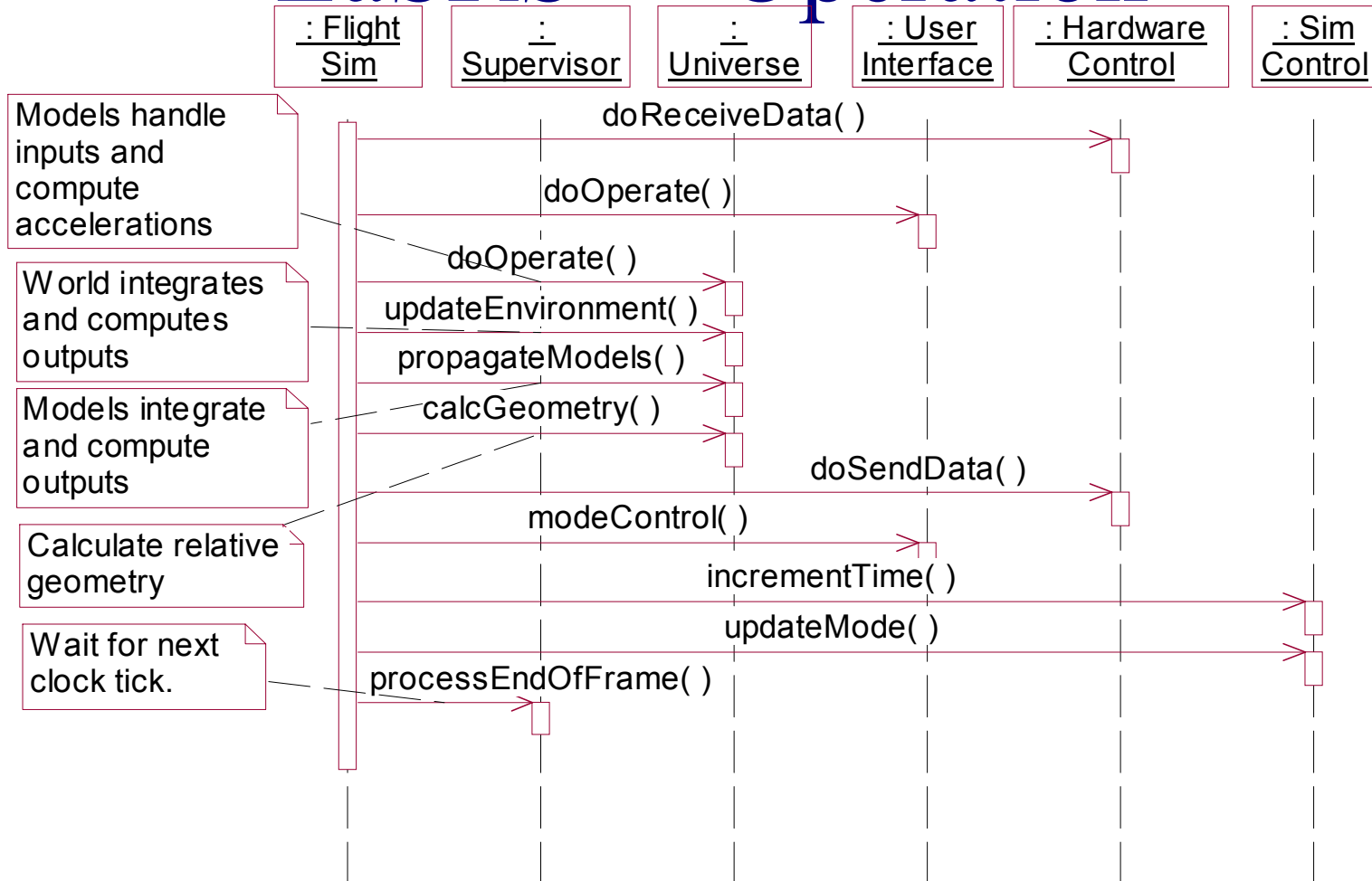
◆ SimControl

- Provides access to mode and simulated time.
- Synchronization for multi-model, multi-CPU operation.

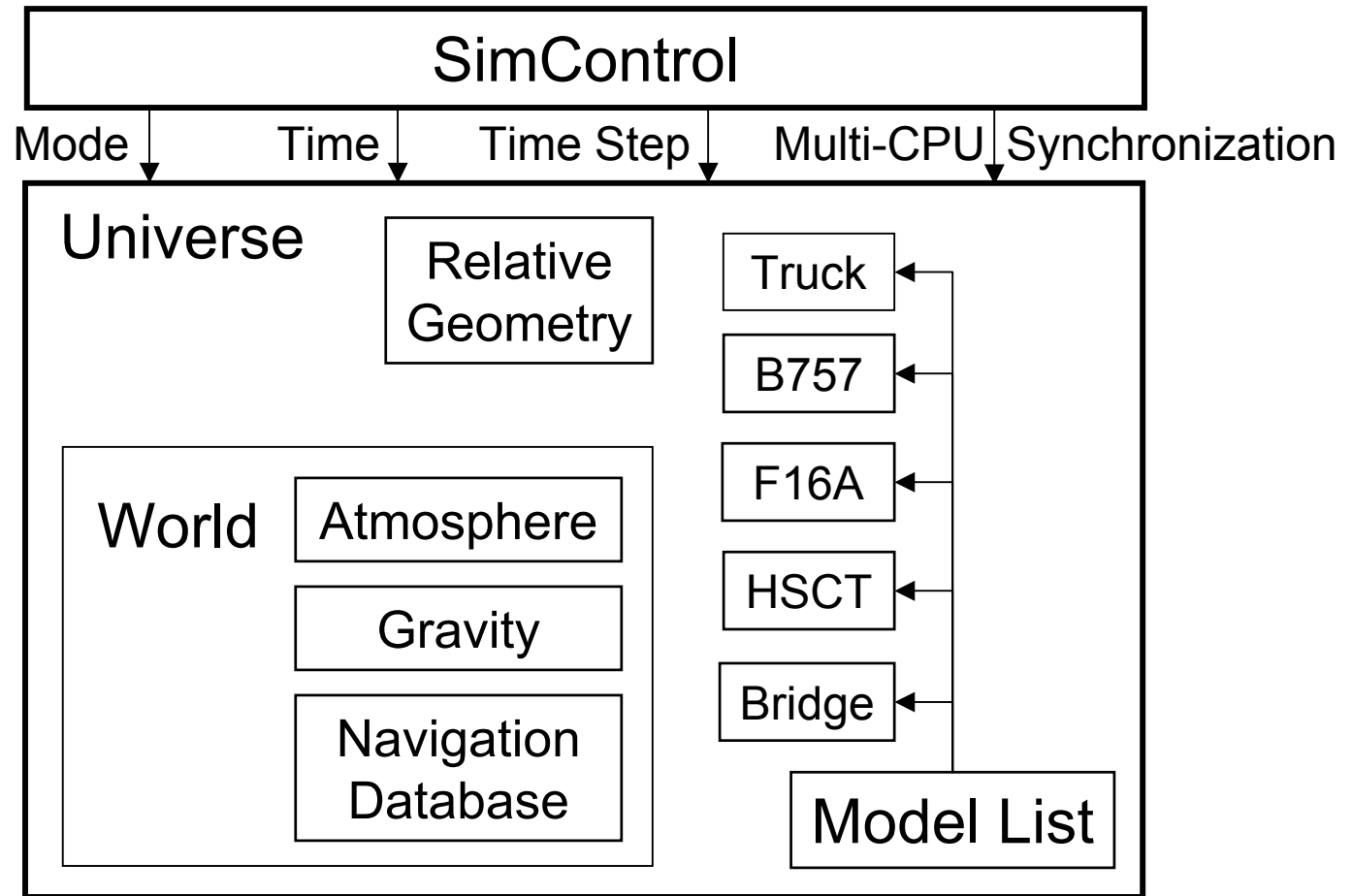
◆ HardwareControl

- Manages hardware drivers and interfaces.

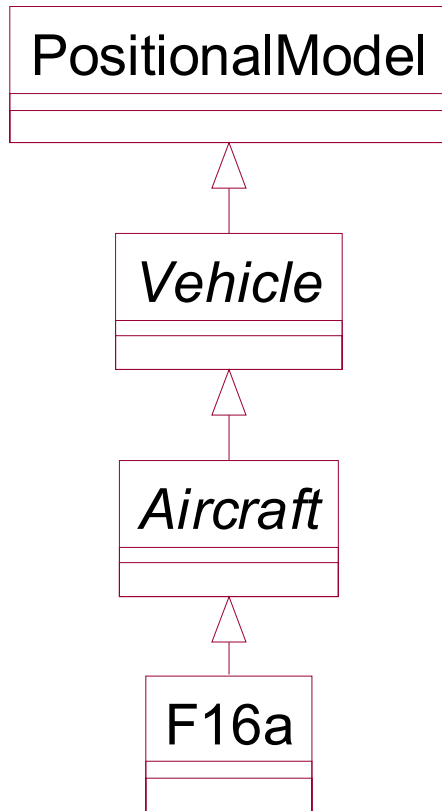
LaSRS++ Operation



Virtual Environment Overview

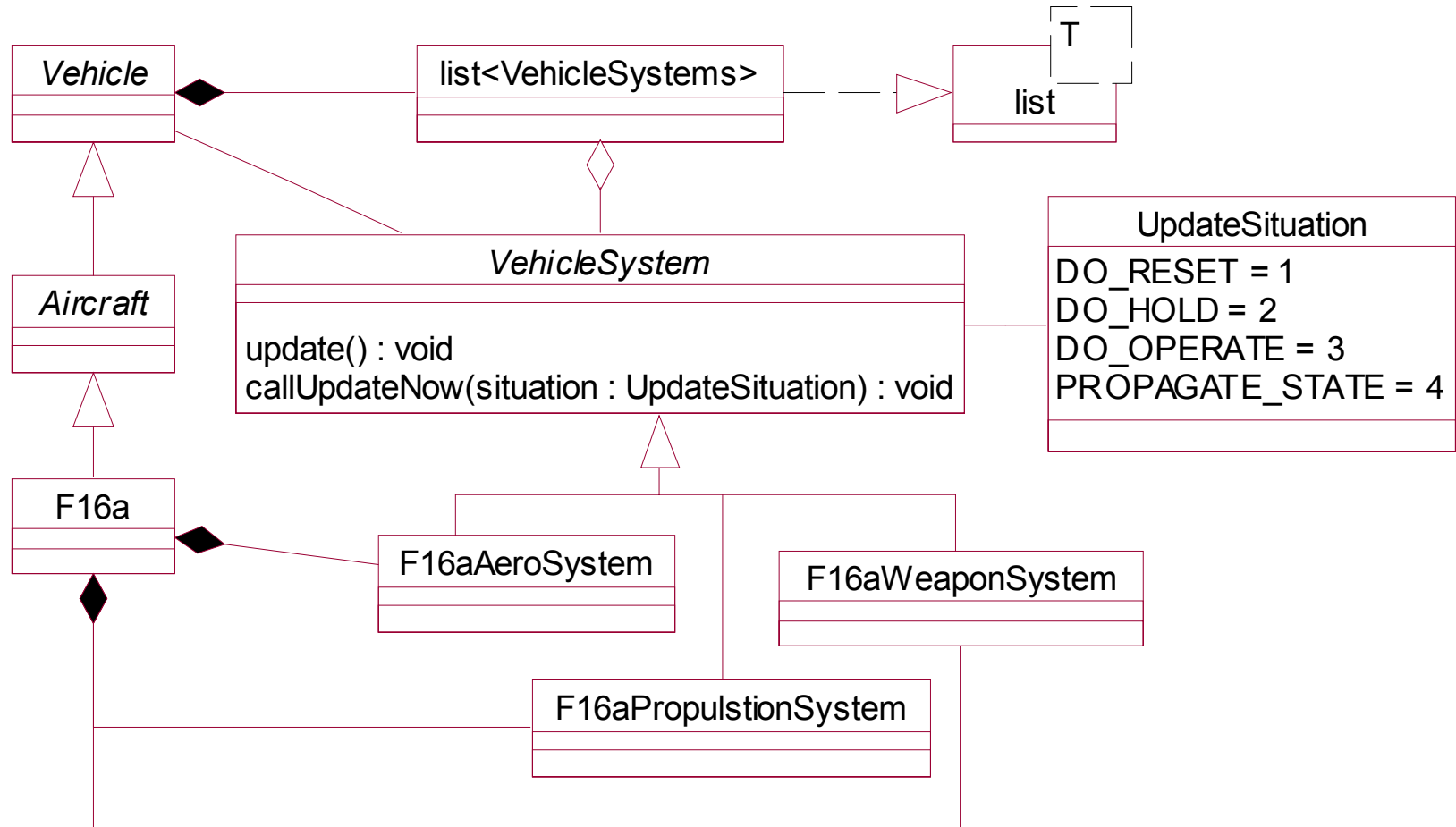


Model Design

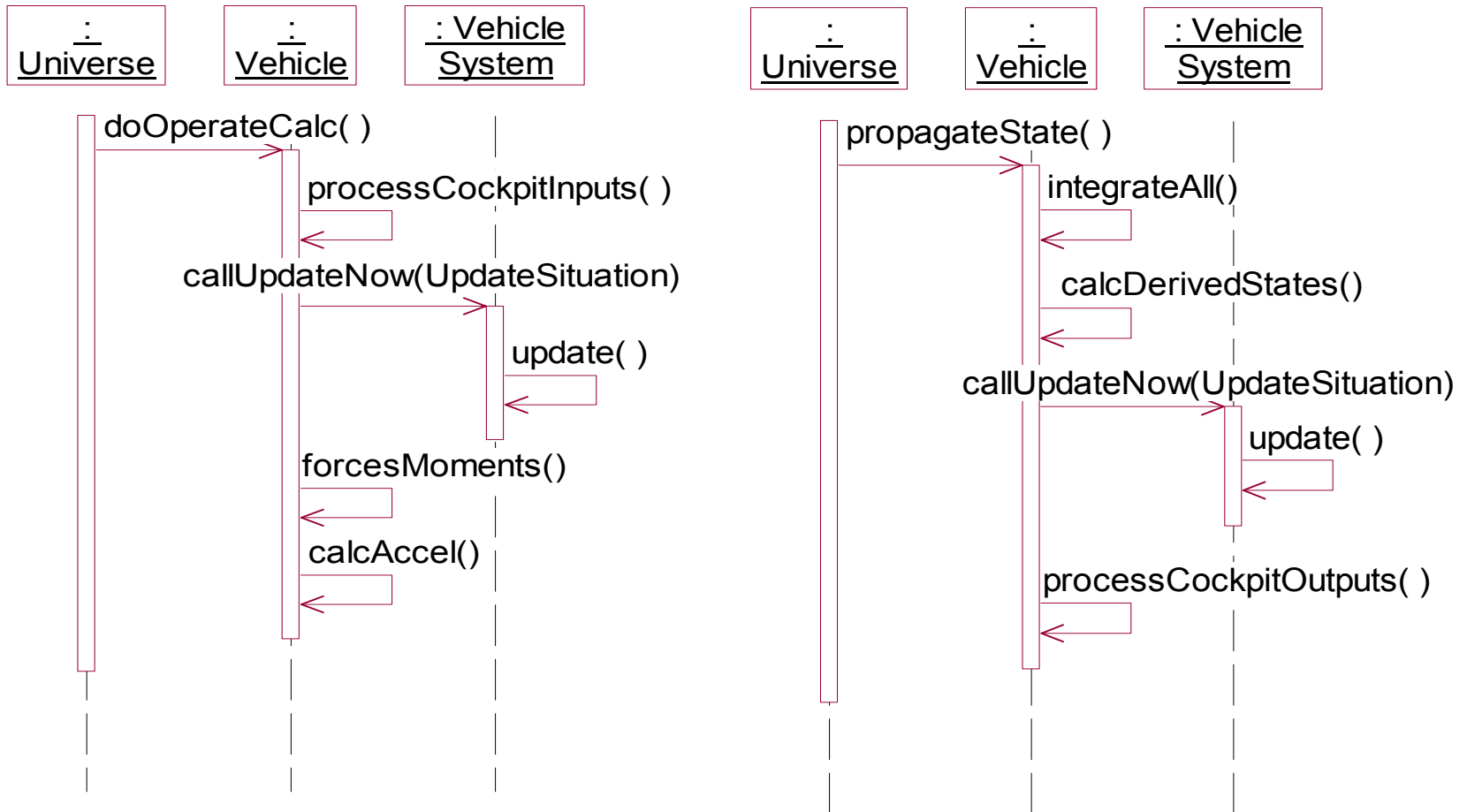


- ◆ PositionalModel occupies a location within the virtual reality and can exhibit movement.
 - Military targets, canned airport traffic, clouds of chemical agents.
- ◆ Vehicle is a PositionalModel that reacts to external forces and moments.
 - Space vehicles and low-speed ground vehicles
- ◆ Aircraft is a vehicle whose external forces and moments are significantly influenced by the atmosphere.
 - Missiles are aircraft.
 - F16a is a type of aircraft.

Vehicle Structure



Vehicle Operation



Supported Simulations

- ◆ F18-E/F Drop Model and Full Scale
- ◆ F18A, F18C, F16A
- ◆ Boeing 757
 - Successful flight tests using LaSRS++ code.
- ◆ General Aviation
- ◆ High Speed Civil Transport (AST-105), HL20, Blended Wing Body, Innovative Control Effectors (ICE-101)
- ◆ In progress
 - F-15A, F18TV, F16XL

LaSRS++ Performance

- ◆ SGI Onyx (195 MHz R10000, 1GB Memory)
 - Boeing 757 up to 100Hz (50Hz Hardware I/O)
 - F18-E/F Drop Model at 180Hz
 - ICE-101 up to 200Hz
- ◆ Double performance numbers for Origin 2000.